



Libera Mission Status and Update
P. Pilewskie & Libera Team

Libera, Earth Venture Continuity-1 Mission

'Li-be-ra, named for the daughter of Ceres in ancient Roman mythology



Provides continuity of the Clouds and the Earth's Radiant Energy System (CERES) Earth radiation budget (ERB).

- Measures integrated shortwave (0.3–5 μm), longwave (5–50 μm), total (0.3–100+ μm) and **(new) split-shortwave (0.7–5 μm) radiance** over 24 km nadir footprint; **uncertainty ~ 0.3%**
- **Includes a wide FOV camera for scene ID and simple ADM generation to pave way for future free-flyer ERB observing system**

Innovative technology:

- **Electrical substitution radiometers (ESRs) using vertically-aligned carbon nanotube (VACNT) detectors**

Primary operational modes:

- Cross-track and azimuthal scanning; on-board calibrators; solar and lunar viewing.

Flight:

- **JPSS-3, 2028 launch; 5-year mission**

Partners:

- LASP, Ball Aerospace, NIST Boulder, Space Dynamics Lab; CU, JPL, CSU, UA, UM, LBL

JPSS-3 Instruments

***Libera* – Earth Radiation Budget**

ATMS - Advanced Technology Microwave Sounder

CrIS - Cross-track Infrared Sounder

VIIRS – Visible Infrared Imaging Radiometer Suite

OMPS – Ozone Mapping and Profiler Suite

***Libera* completed Preliminary Design Review 8-10 Feb. 2022**

***Libera* passed KDP-C 12 April 2022**

Libera Major Reviews and Key Milestones

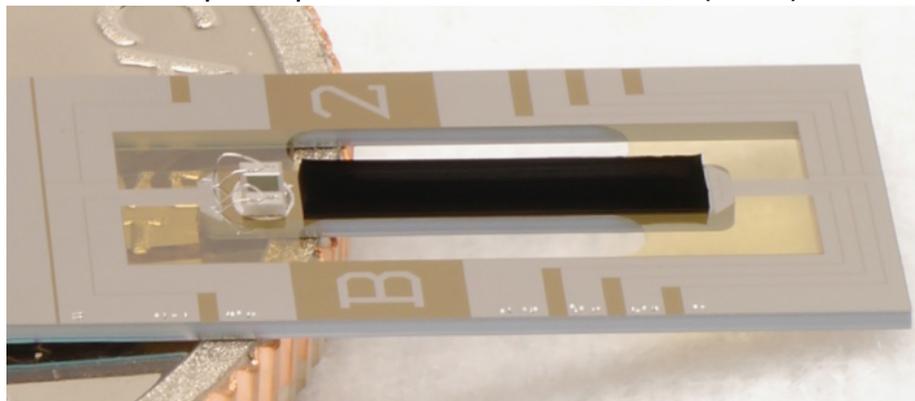
Milestone	Acronym	Date	Convening Authority
Authorization to Proceed	ATP	6 Jul 20	-
System Requirements Review	SRR	22 Feb 21	SRB
Key Decision Point - B	KDP-B	30 Apr 21	SMD PMC
Preliminary Design Review	PDR	8-10 Feb 22	SRB
Key Decision Point - C	KDP-C	Apr 22	SMD PMC
Critical Design Review	CDR	Feb 23	SRB
Instrument Integration Review	IIR	Jun 24	SRB
Pre-Environmental Review	PER	Oct 24	SRB
Pre-Ship Review	PSR	Mar 25	SRB
Delivery to Spacecraft		May 25	-
Key Decision Point D	KDP-D	Jun 25	SMD PMC
Launch		2027	-
Key Decision Point E	KDP-E	2027	SMD PMC
Post Launch Assessment Review	PLAR	L+90d	SRB
Operational Transition Review	OTR	PLAR + 9mo	TBD

ERB Continuity

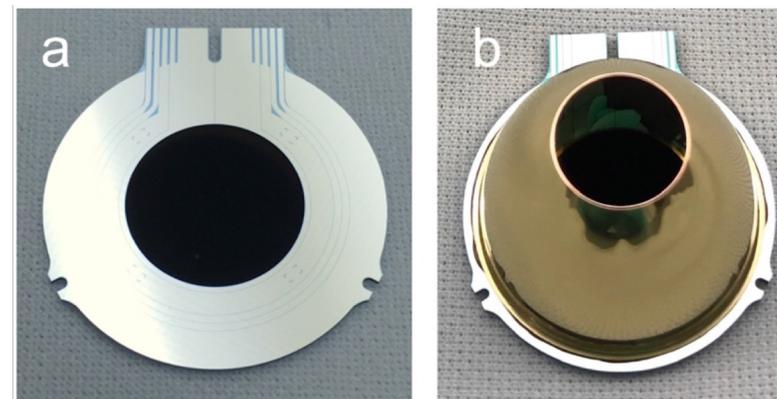
- CERES, the longest continuous global observational record of ERB, started in 2000.
- Six CERES instruments are in orbit flying aboard the Terra, Aqua, Suomi National Polar orbiting Partnership (SNPP) and NOAA-20 satellites.
- *Five of the six CERES instruments are well beyond their nominal five-year design lifetime.*
 - By late 2027, when JPSS-3 is currently scheduled to launch, there is a 38% probability that a data gap in the ERB record will occur regardless of the various decommissioning scenarios for Terra, Aqua and SNPP.
 - Gap-filling methods using imagery data will have uncertainty on the order of current decadal trends; time-to-detection is compromised
 - The current ERB data record depends on continuity and overlap to align measurements from different instruments. A gap increases uncertainty in the composite.

VACNT ESRs for Climate Studies

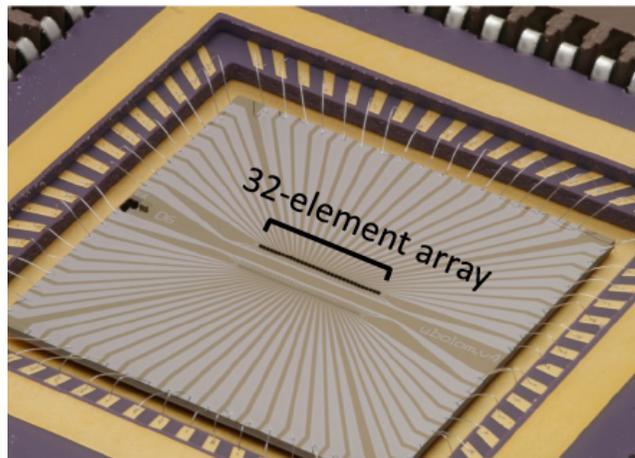
Compact Spectral Irradiance Monitor (CSIM)



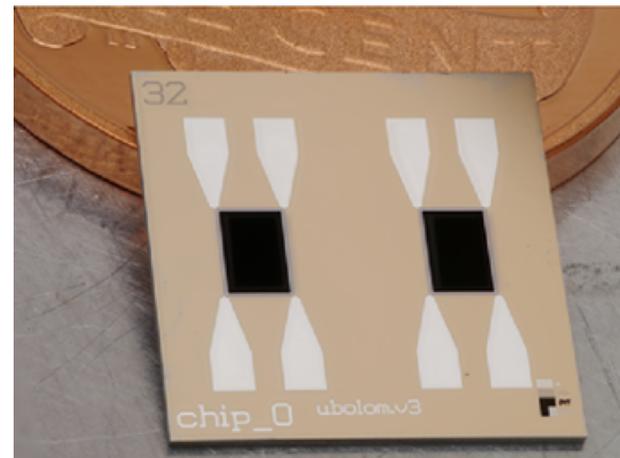
Compact Total Irradiance Monitor (CTIM)



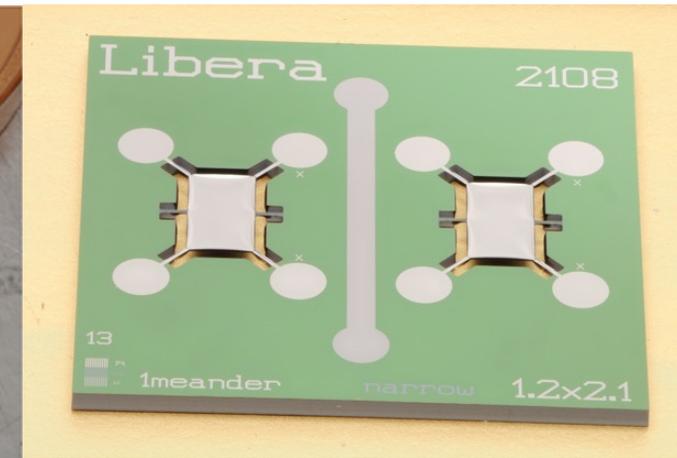
Black Array of Broadband Absolute Radiometers (BABAR)



Libera Prototype 0



Libera Prototype 4

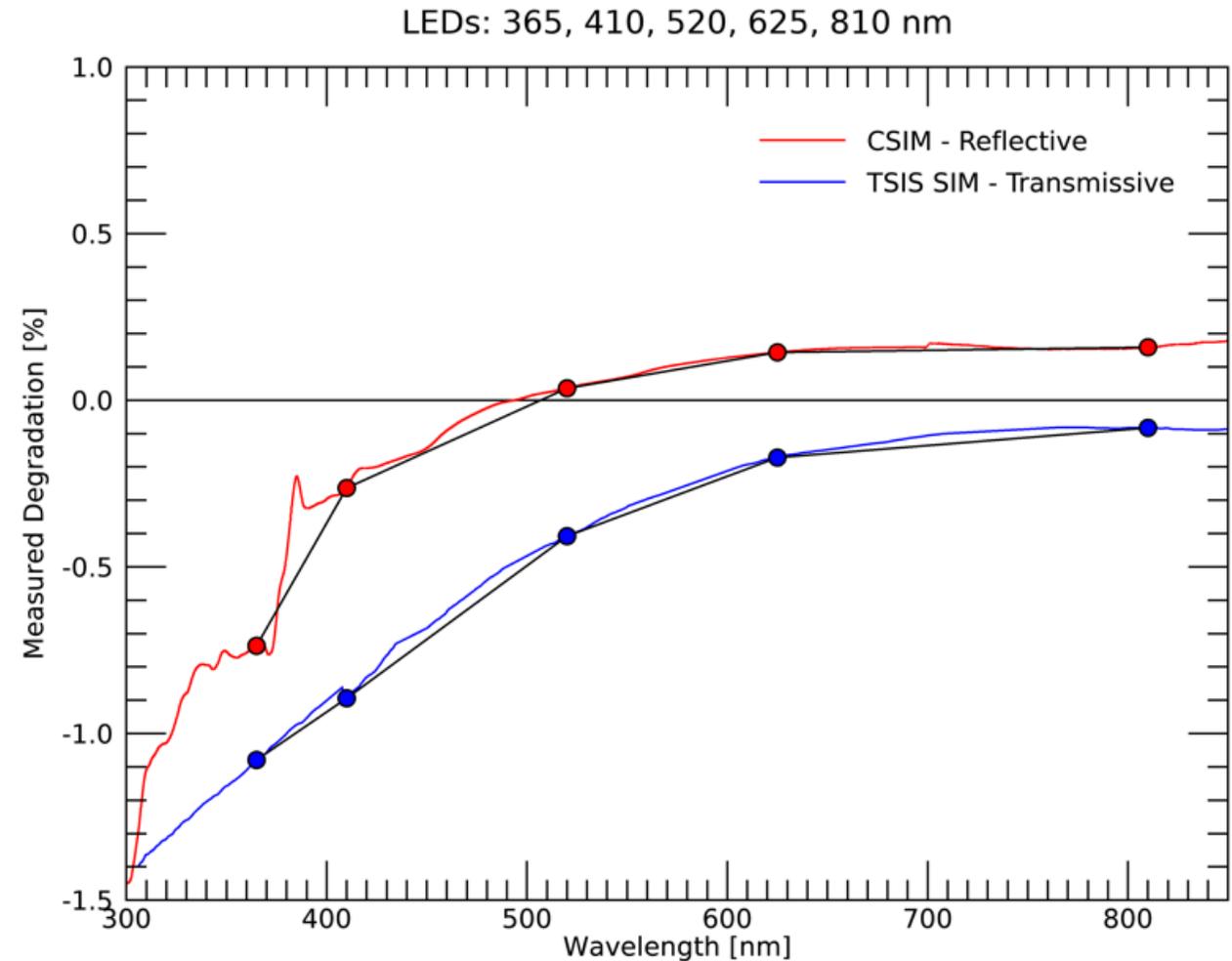


SW Calibration System

- Tracks changes in SW spectral response of science radiometers
- LEDs at six wavelengths:
 - 365, 410, 520, 625, 810, 1550 nm
- LED Radiance Monitor
 - SW Calibration Radiometer (SWCR)
 - Replica of total radiometer
- Radiometer Scan Mirror (RSM) sweeps SW LED radiance between SWCR and science radiometers
- Primary mode of long-term drift is degradation of the SWCR optics
 - Inherent SWCR detector stability $<0.01\%/year$
 - Keep optics degradation $<0.01\%/year$
- UV exposure rate of the SWCR is 1000 times less than science radiometers

Wavelength Selection

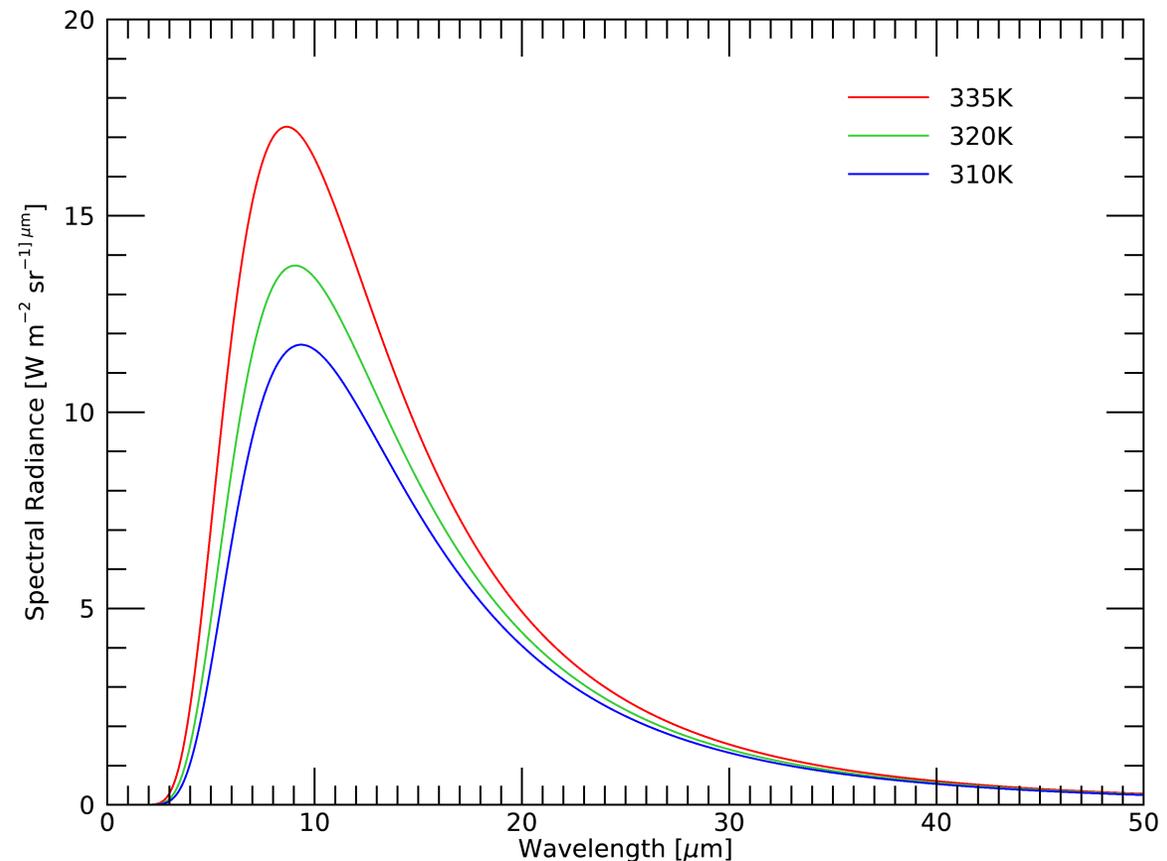
- Wavelengths chosen to capture expected wavelength dependence
- Measured optical degradation between redundant channels on TSIS-1 SIM (blue) and CSIM (red)
- Similar spectral shape
- Degradation with reflective first optic (CSIM) can show *increase* in reflectivity with optical degradation



LW Calibration System

- On board thermal calibration source for LW and TOT telescope channels
 - Will also monitor longwave contribution to SW and SSW radiometers.
- LWC will maintain a constant temperature at 310 K and will be varied between 310-335 K periodically to test response linearity

Temperature [K]	Integrated Radiance [W m ⁻² sr ⁻¹]
335	227
320	189
310	167



Libera Algorithm Theoretical Basis Document (ATBD)

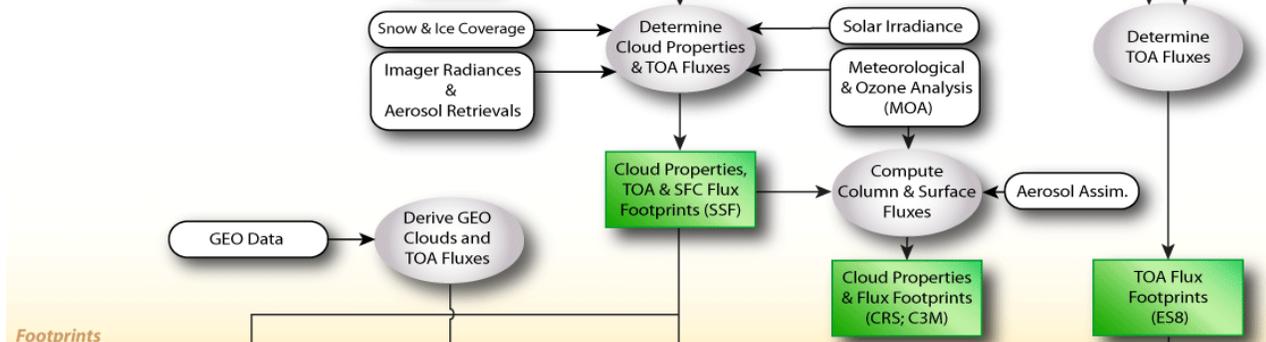
Section#	Product or Processing	ATBD content	Lead
1	L-1b Radiometer Radiances	Instrument calibration and operations	D. Harber
2	Geolocation	Radiometer and camera	S. Beland
3	L-1c Unfiltered Radiometer radiances	VIS and NIR	P. Pilewskie
4	L-1b Camera radiances	Instrument, calibration and operations	S. Schmidt
5	L-2x Cloud fraction	Adaptive thresholding + camera	S. Schmidt
6	ADMs for split channel	ADM formulation & binning	J. Gristey
7	L-2x TOA SW, VIS, NIR fluxes	Instantaneous foot print (limited regions); Scene ID with camera/VIIRS CF VIIRS & (new) ERBE ADMs	M. Hakuba
8	L-2 TOA Far-IR fluxes	Instantaneous foot print; includes ADMs	X. Huang
9	L-2 SUR fluxes SW, NIR, VIS	Computed TOA and SUR fluxes SSF; validation approach	X. Dong

CERES Data Processing Flow

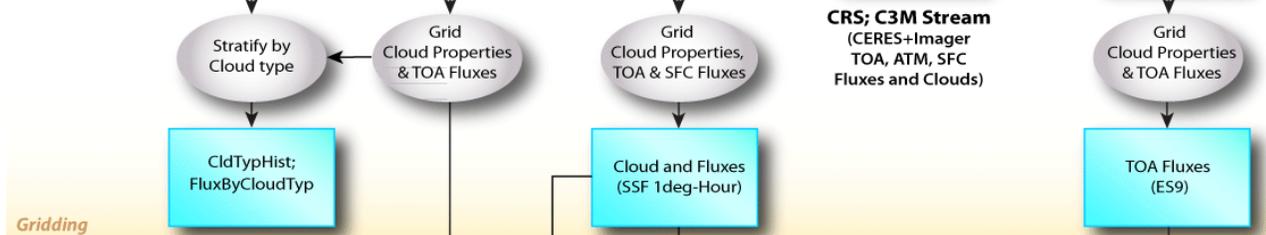
L0, L1b



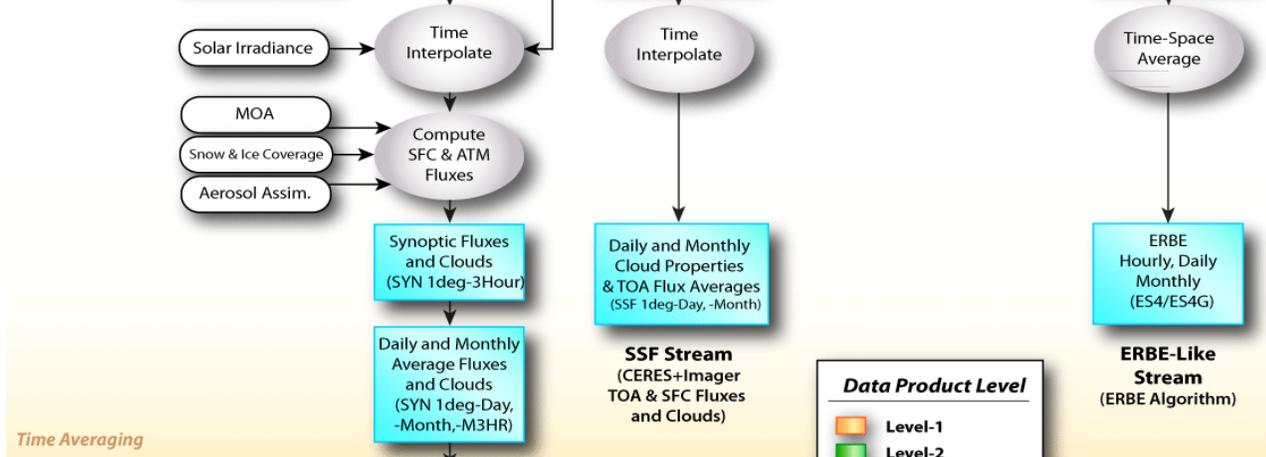
L2



L3



L3



L3b



Data Product Level

- Level-1
- Level-2
- Level-3
- Level-3b
- Algorithm
- Ancillary Data Set

Coordination Between *Libera* and RBSP

- Weekly meetings between LASP and RBSP
- Calibration and Validation working group oversees ground and on-orbit calibration activities. Interface between LASP, technical partners at Ball, NIST and SDL and the RBSP.
- The *Libera*/RBSP/ASDC Data Management Working Group oversees the production and distribution to the RBSP and ASDC of *Libera* level 1-b data and metadata.
- The *Libera*/RBSP Operations Working Group will manage the *Libera* concept of operations before and during the year-1 Phase E operations effort.

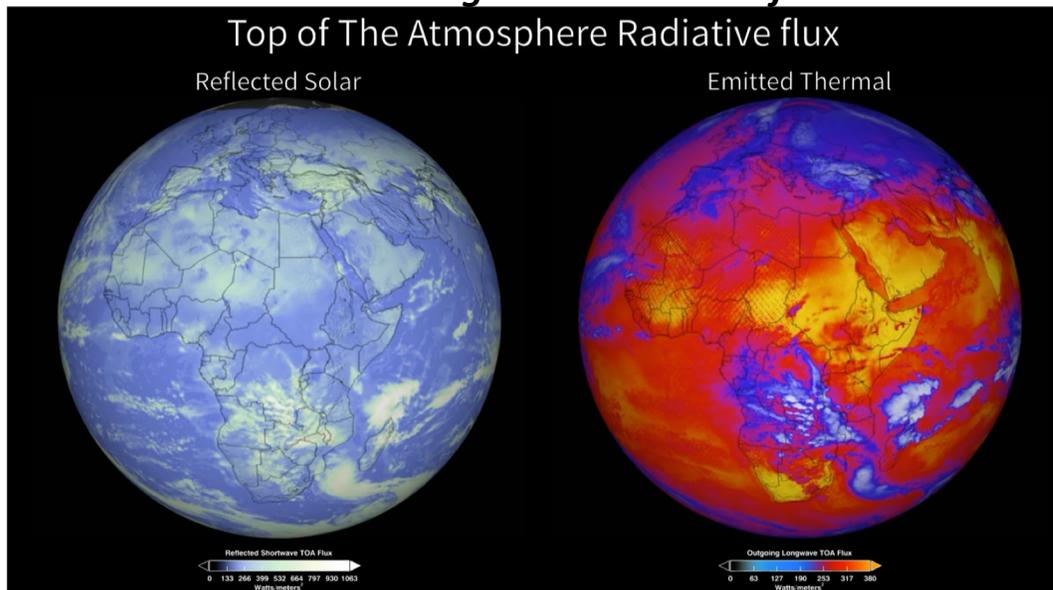
All part of the *Libera* Earth Radiation Budget Continuity Plan

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Earth Radiation Budget Observations from CERES

Top of The Atmosphere Radiative flux



Joint Polar Satellite System-3



Libera continues the 22-year CERES Climate Data Record for the Earth Radiation Budget (ERB).

- *Measures reflected solar and emitted infrared radiation from Earth*
- *Provides fundamental climate information about the balance between incoming and outgoing energy from Earth*
- *Continuity of this climate record over time reveals the signals of climate change – connects temperature trends to energy flow*

Libera is Innovative:

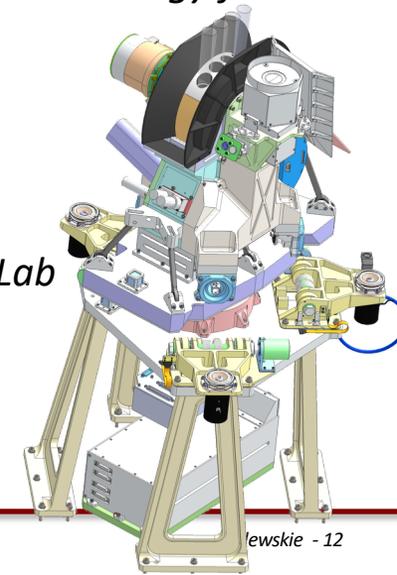
- *Uses state of the art detectors with carbon nanotube technology, the blackest substance on Earth*
- *Adds a split-shortwave measurement to isolate where energy from the Sun is deposited in the Earth system.*
- *Adds a wide-field-of-view camera to support split shortwave science*

Partners:

- *LASP, Ball Aerospace, NIST Boulder, Space Dynamics Lab*
- *Science Team: CU, JPL, CSU, UA, UM, LBL*

Flight:

- *JPSS-3, 2027 launch; 5-year mission*



Thanks!